INVESTIGATION ON MECHANICAL PROPERTIES OF LIGHTWEIGHT AGGREGATE CONCRETE CONTAINING COAL ASH AS PARTIAL SAND REPLACEMENT

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Peningkatan permintaan dalam penggunaan elektrik dan pengeluaran dari industri kelapa sawit telah menyumbang kepada peningkatan pengeluaran bahan buangan. Permintaan tinggi arang batu oleh loji kuasa, meningkatkan pengeluaran abu arang batu. Malaysia sebagai pengeksport minyak kelapa sawit terbesar dunia juga telah menghasilkan sejumlah besar sisa pepejal dan boleh menjadi punca masalah persekitaran. Selain daripada meluaskan tapak pelupusan yang ada, penggunaan bahan buangan adalah sangat berguna kerana memerlukan kos yang lebih rendah. Oleh itu, penggunaan bahan buangan dalam industri pembinaan meningkatkan peluang dalam menyelesaikan masalah persekitaran. Dalam kajian ini, siasatan telah dijalankan untuk mengetahui kekuatan mampatan, kekuatan lenturan dan modulus keanjalan konkrit agregat ringan yang mengandungi abu dasar arang batu sebagai pengganti pasir separa. Permukaan tepu kering tempurung kelapa sawit digunakan sebagai agregat kasar. Abu dasar arang batu digunakan sebagai pengganti pasir separa untuk 0%, 10%, 20% dan 30%. Semua konkrit diawet dengan kaedah awetan udara. Ujian kekuatan mampatan dan ujian kekuatan lentur dilakukan pada 7 hari, 28 hari dan 60 hari. Sementara itu, modulus ujian keanjalan dilakukan pada 28 hari. Berdasarkan tiga ujian yang dijalankan, boleh dibuat kesimpulan bahawa kekuatan maksimum konkrit mencapai 10% penggantian pasir oleh abu dasar arang batu. Kekuatan konkrit mula berkurang dengan peningkatan peratusan abu dasar arang batu. Sebagai kesimpulan, penggantian optimum abu dasar arang batu boleh digunakan untuk menghasilkan kekuatan konkrit yang lebih tinggi.

ABSTRACT

The increasing demand for electricity consumption and the production from oil palm industry have contributed to increasing the production of waste materials. The high demand for coal by power plants, increase the production of coal ash. Malaysia as the world largest exporter of oil palm shell also have produced a vast amount of solid waste and can be a cause of the environmental problem. Instead of expanding the available landfill, the utilization of the waste materials would be very useful since it required a lesser cost. Rather than that, utilization of these waste materials in construction industry increase chances in solving environment problem. In this study, investigations have been carried out in order to figure out the compressive strength, flexural strength, and modulus of elasticity of oil palm shell lightweight concrete containing coal bottom ash as partial sand replacement. Saturated surface dry oil palm shell was used as coarse aggregate in the concrete. Coal bottom ash was used as partial sand replacement for 0%,10%, 20%, and 30%. All specimens were subjected to air curing method. The compressive strength test and flexural strength test were conducted at 7-day, 28-day, and 60-day. Meanwhile, modulus of elasticity tests was conducted at 28-day. Based on the three tests conducted, it can be concluded that the strength of the concrete reaches the maximum with 10% partial replacement of sand by coal bottom ash. The strength of the concrete started to decrease with increasing percentage replacement of coal bottom ash. As a conclusion, the optimum replacement of coal bottom ash can be used to produce higher concrete strength.

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LIST OF SYMBOLS

P	The maximum load at failure
A	The cross-sectional area of cube
fcf	Flexural strength
F	Maximum Load
ℓ	Distance between supporting rollers
d_1, d_2	The lateral dimensions of the specimens

LIST OF ABBREVIATIONS

MgO	Magnesium Oxide
C_3S	Tricalcium Silicate
C_2S	Dicalcium Silicate
C_3A	Tricalcium Aluminate
C_4AF	Tetra calcium Aluminoferite
CO^2	Carbon Dioxide
SiO_2	Silica
Fe_2O^3	Ferric Oxide
CaO	Calcium Oxide
K_2O	Potassium Oxide
P_2O_5	Phosphorus Pentoxide
SO_3	Sulphur Trioxide
SrO	Strontium Oxide
Al_2O_3	Aluminium Oxide
Cl	Chloride
LOI	Loss on ignition

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Nowadays, concrete is an important element in the construction of a building. In the 21st century, 11 billion people will be living on the earth and that clearly proves that as the population increases, the more common goods and services are needed. Meanwhile, agricultural wastes and solid material disposal are giving serious damage to the environment. Since Malaysia recorded as the highest amount of solid waste produced through palm oil industry in a year which is 47 million tonnes, to some extent, it can be the cause of the environmental problem (Pordesari, et al., 2016). In countries, where abundant agricultural wastes are discharged, these wastes can be used as potential materials or replacement material in the construction industry. The oil palm shell is one of the wastes and has potential to be used as coarse aggregate in concrete (Mannan and Ganapathy, 2002). Oil palm shell had been successfully used as lightweight coarse aggregate in order to achieve the structural grade lightweight concrete and high strength lightweight oil palm shell concrete (Islam et al., 2016).

Coal ash is residue resulting from the combustion of pulverized coal or lignite in a thermal power plant. The burnt coal produces smoke which goes into the air is captured as fly ash, meanwhile, the burnt coal at the bottom of the burning chamber that is cooled is called bottom ash. There is six thermal power plant operated in Malaysia with an annual coal consumption of 24.7 million tonnes. The production of coal and wastes are increasing due to the high demand for coal consumption. Coal-fired plants generate waste by-product such as coal bottom ash through the generation of electricity is normally sent to landfill. Therefore, an excessive amount of waste should be used to produce concrete that is lightweight, economic and environmental friendly towards the sustainable production in the construction industry (Sadon, et al., 2017).

1.2 Problem Statement

Malaysia as the world's largest exporter of palm oil, facing problem in the processing of palm oil that produced a large amount of by-product such as oil palm shell. In 2011, 18 million tonnes of palm oil products were exported. Malaysia produces 18.79 million tonnes of crude palm oil on roughly 5 million hectares of land (Yew, et al., 2014). This by-product is one of the main contributors to the pollution problem. A large amount of oil palm shell waste materials is stockpiled and dumped. Oil palm shell is generated approximately 6.89 million tonnes every year (Muthusamy and Zamri, 2016). These have created a major disposal problem (Abdullah and Sulaiman, 2013). This large amount of waste material produced should be used as an alternative to producing lightweight concrete.

Other than that, a fast-developing country with thriving economies has increased demand for the use of electricity in Malaysia. Tenaga Nasional Berhad (TNB) consumed 1.5 million tonnes of coal each year. Meanwhile, in 2016, peninsular Malaysia recorded as 29 million tonnes of annual coal consumption of power sector (Sadon, et al., 2017). Coal bottom ash that is generated from electricity generation by the coal-fired plant will be sent to landfills. Disposal of coal bottom ash has become a major problem due to insufficient dumping sources and cause environmental hazards (Singh and Siddique, 2013). The production of coal bottom ash increased as well as the consumption of coal by power plants increases.

1.3 Objectives of the Study

The objectives of this study are to:

i. To determine the compressive strength of oil palm shell lightweight concrete using containing coal bottom ash as partial sand replacement.

ii. To determine the flexural strength of oil palm shell lightweight concrete using containing coal bottom ash as partial sand replacement.

iii. To determine the modulus of elasticity of oil palm shell lightweight concrete using containing coal bottom ash as partial sand replacement.

1.4 Scope of Research

The scope of this study focused on the alternatives to produce lightweight concrete using oil palm shell as coarse aggregate containing coal bottom ash as partial replacement of sand at different percentage replacement 0%, 10%, 20% and 30% of the sand volume. This study used characteristics of the concrete grade of 30 MPa. Oil palm shell was chosen to be the waste material to be used to produce lightweight concrete. This study also focused on using air type curing. The compressive and flexural strength of the concrete was tested at the days of 7, 28 and 60 days, meanwhile, the modulus of elasticity of the concrete was tested at 28-day based on curing period. The tests were carried out in Concrete Laboratory in Universiti Malaysia Pahang.

1.5 Significance of Research

Since the production of coal bottom ash and oil palm shell are increasing, the utilization of the waste materials would be very useful instead of expanding the available landfill. Utilization of these industrial by-products would be economical rather than expanding the landfill that probably needs much cost. The higher production rate of the waste makes it necessary to reuse the wastes for sustainability. Besides the environmental problem can be solved, it is significant to grab the opportunity especially in the construction industry as their large amount of production.

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